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ANALYSIS OF ATTACK AS(SSN) TENDER LOAD LIST MODEL,(U)
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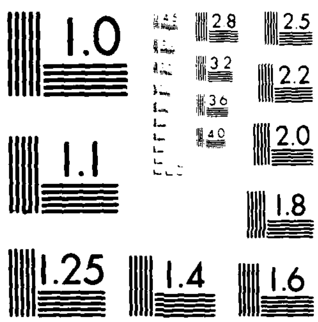

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ANALYSIS OF ATTACK AS(SSN) TENDER LOAD LIST MODEL

REPORT NO. 150

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ABSTRACT

This study evaluated (1) alternative techniques for computing AS(SSN) tender load lists and (2) alternative range and depth criteria unique to the La Maddalena based tender load list. The various alternative test loads were evaluated using actual demand for a 90 day period. The models were evaluated in terms of units, requisitions, and range effectiveness. It is recommended that (1) if an increase in range can be accommodated, the AS(SSN) load list be built with a demand-weighted units short optimization model for equipment-related items and a demand-weighted requisitions short optimization model for nonequipment-related items and (2) the La Maddalena site tender load be built using the full demand forecast vice a factored demand for depth, with the range cut increased from four to six or eight. It is also recommended that there be separate goals for Depot Level Repairables, equipment-related items, and nonequipment-related items.

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EXECUTIVE SUMMARY

1. Objective. The objective of this study is twofold. First, a general evaluation of the AS(SSN) tender load list model was performed. Secondly, alternative range and depth criteria unique to the La Maddalena site load list were evaluated.

2. Approach. The current Attack AS(SSN) model assumes that the Normal probability distribution describes item demand. The load list range is determined by a range cut based on predicted Average Quarterly Demand (AQD). Depth is computed using a variable protection model based on essentiality-weighted requisitions short. For items with demand history, demand is used in lieu of a measure of essentiality. Otherwise, essentiality is based on the vital/nonvital Military Essentiality Code (MEC). The load is built to satisfy separate 85% net requisition effectiveness goals for Equipment-Related (ER) and Nonequipment-Related (NER) items.

All test loads built for the general model analysis portion of the study were based on the USS SPERRY (AS 12) candidate file provided by SPCC and two years of demand history from the supported submarines. These test loads were built to evaluate alternative range criteria, probability distribution assumptions, risk constraints, depth rounding rules, risk criteria, demand forecasting techniques for ER items, and depth constraints for items with no historical demand.

The difficulty in building the La Maddalena based tender load list is that although the load is built to support 37 submarines, only about nine submarines will be supported in a given calendar quarter. Thus, the current model range and depth may be too large. The test loads built for the La Maddalena load

analysis were based on the USS ORION (AS 18) candidate file and two years of demand. Alternative depth criteria were evaluated by varying the percent of AQD used in the depth determination. An alternative range criterion was also evaluated. This alternative was based on a range cut determined by the probability that an item would be demanded by one of the nine submarines supported by the USS ORION during a 90 day period.

The test loads for both parts of the study were evaluated by comparing the computed load list quantities to 90 days of actual demand data. The effectiveness measures used in this analysis were range effectiveness, net and model requisition effectiveness, and net and model units effectiveness.

4. Findings and Recommendations.

a. General Evaluation. Results indicate that the most cost-effective models are optimization models (no range cut). For ER items, it is recommended that a units short optimization model, built with the Poisson/Normal distribution and a cost goal or higher effectiveness goal, be implemented. If the resulting 50% increase in range can not be accommodated, it is recommended that the current model be retained with the rounding rule changed to always round up. For NER items, a requisitions short optimization model is recommended that is built with either the Normal or Poisson/Normal distribution and an effectiveness goal. These recommendations are generally consistent with FMSO Operations Analysis Report 130. It is also recommended that there be separate goals for Depot Level Repairables (DLRs), ER and NER items.

b. La Maddalena Analysis. The range alternative had little impact on cost or effectiveness. The most cost-effective depth alternative, and the one recommended, was built by applying a 1.0 factor (vice .25) to the AQD for depth purposes and increasing the range cut from four to six or eight.

I. INTRODUCTION

This study consists of two parts. The first part evaluated possible changes to the current Attack AS(SSN) tender load list model. The current AS(SSN) load list model uses a range cut (currently four demands in two years) based on predicted Average Quarterly Demand (AQD) to achieve the desired range of load list items. The model assumes that the Normal probability distribution describes item demand. Depth is computed using a variable protection routine based on essentiality-weighted requisitions short. For items with historical demand in a specified 24 month period, demand is used in lieu of a measure of essentiality. Otherwise, essentiality is based on the vital/nonvital Military Essentiality Code (MEC). The load is built to meet separate 85% net requisition effectiveness goals for Equipment-Related (ER) and Nonequipment-Related (NER) items. The load represents a 90 day support level assuming no resupply. Areas that were evaluated included:

- Techniques for determining range
- Probability distribution assumptions
- Risk constraints
- Depth rounding rules
- Risk criteria
- AQD computation for ER items
- Depth constraints for items with no historical demand

A similar study was documented in reference (a). That study recommended the use of a common model for computing conventional and Fleet Ballistic Missile (FBM) submarine tender load lists. That recommendation has not been implemented as yet.

The second part of the study evaluated test loads built for the USS ORION, the La Maddalena-based tender. During the last production cycle for the USS ORION, concern was expressed over the computed load list quantities. The unique problem in building the La Maddalena load was that although the load was built to support 37 submarines, only about nine submarines were to be supported in a given quarter. Thus, the load list depth originally computed for the USS ORION was assumed to be too large. Consequently, this part of the study evaluated unique range and depth criteria for the La Maddalena site load list. It should also be noted that each of the 37 submarines receives primary support elsewhere.

II. APPROACH

The test load lists for analyzing the AS(SSN) load list model were based on the AS 12 (USS SPERRY) candidate file provided by Navy Ships Parts Control Center (SPCC) and two years of demand history from the supported submarines. Similar data for the AS 18 (USS ORION) were used to build test loads for the La Maddalena load list analysis.

The test loads were built to satisfy separate effectiveness goals for ER and NER items of 85% net requisition effectiveness. An item is considered ER when it is on the Inventory Control Point (ICP) candidate file of Allowance Parts List (APL) items. The ER candidate items include items with and without historical demand. An item is considered NER if it has historical demand but it is not on the ICP candidate file.

The test load lists were then evaluated by comparing 90 days of actual demand data to the load list quantities. The effectiveness used in this analysis were range effectiveness, net and model requisition effectiveness, and net and model units effectiveness. These effectiveness measures are defined as follows:

- Range Effectiveness. The number of load list items demanded divided by the total candidate items demanded. Demands for items not on the candidate file were excluded from the effectiveness computations.
- Net Requisition Effectiveness. The number of requisitions for load list items demanded and satisfied divided by the number of requisitions for load list items demanded.
- Model Requisition Effectiveness. The number of requisitions for load list items demanded and satisfied divided by the total number of requisitions demanded for candidate items. Demands for items not on the candidate file were excluded from the effectiveness computations.
- Net Units Effectiveness. The number of units for load list items demanded and satisfied divided by the number of units for load list items demanded.
- Model Units Effectiveness. The number of units for load list items demanded and satisfied divided by the total number of units demanded for candidate items. Demands for noncandidates were excluded from the effectiveness computations.

A note of explanation is in order for the term "Model Effectiveness". Model effectiveness only considers demand for items that appear on the SPCC candidate file. Gross effectiveness, as usually defined, considers all demand, candidate and noncandidate. This study considered model, vice gross, effectiveness because the statistics were broken out by ER and NER. Demands for noncandidates are not identified as ER or NER.

For purposes of this study, differences in effectiveness between alternatives of less than one percentage point are not considered significant.

III. ANALYSIS OF THE AS(SSN) TENDER LOAD LIST MODEL

A. AS 12 Candidate File Analysis. The AS 12 test loads were based on demand history from the supported submarines for the two year period March 1977 through February 1979. There were 94,244 ER candidates for the AS 12. Only 12,847(14%) of these ER candidates had historical demand during the selected two year period. Demand forecasts for the remaining 81,412 ER candidates were based on the item's Best Replacement Factor (BRF) and population. Characteristics of the ER candidates are shown in Appendix B and summarized below:

- Over 91% (85,965) of the ER candidates had an AQD of 1.00 or less; i.e., four units or less a year.
- Over 92% (86,929) of the ER candidates had an average requisition size of zero or one.
- 22% (20,852) of the ER candidates had a unit price of $1 or less and almost 80% had a unit price of $100 or less.
- 90% (84,727) of the ER candidates had a ship MEC of 116 (highest possible).
- 89% (84,006) of the ER candidates had a zero tender MEC. Of the 10,238 having a tender MEC, all but 10 had a tender MEC of 58 (highest possible). It is noted that a tender MEC of zero means that there is no tender installable application.

There were 17,624 NER candidates for the AS 12. Of these, 7,124 were excluded by policy because they had only a single demand frequency in two years or a total two year demand quantity of four units or less. Thus, 10,500 NER candidate items were considered in this study. Characteristics for these items are shown in Appendix C and summarized below:

- Over 38% (4,075) of the NER candidates had an AQD greater than one.
- Over 52% (5,485) of the NER candidates had an average requisition size of zero or one.

- Over 28% (3,005) had a unit price of $1 or less and almost 90% (9,377) had a unit price of $100 or less.

The loads were evaluated using demand requested by the submarines in the hull mix and by the AS 12 for the 90 day period July through September 1979. These data are assumed to be representative of a typical quarter. TABLE I displays the characteristics of these demand data.

TABLE I

Demand Characteristics
(Jul - Sep 1979)

Item Category	Items Demanded	Nr of Requisitions	Nr of Units
Candidates	7,813(71.2%)	21,394(82.8%)	278,980(85.1%)
Noncandidates	3,167(28.8%)	4,443(17.2%)	48,799(14.9%)
Total	10,980	25,837	327,779

The table shows that over 70% of the items and over 80% of the requisitions and units demanded had National Item Identification Numbers (NIINs) identified on the candidate file.

B. Model Analysis.

1. Risk Constraints. The current model provides for each item a protection level ranging from 2% to 98%, depending on an item's demand forecast and unit price. An item with a protection level of less than 50% will have a computed load list quantity less than the expected quarterly demand. In effect, that item would have negative safety level. An alternative test load was built to eliminate negative safety levels. This load was built by increasing the minimum protection level from 2% to 50%. Thus, under this model, a load list item would be stocked to a depth at least as large as its expected demand. TABLE II

compares the benchmark with this alternative load. Both models were built to satisfy separate 85% net requisition effectiveness goals for ER and NER items.

TABLE II
Comparison of Alternative Risk Constraints

	Alternatives	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
ER	Benchmark	14,730	$2,418.4K	63.1%	59.7%	68.5%	77.7%	62.6%
	No Neg Safety Level	14,730	$3,028.9K	62.8%	60.2%	68.2%	78.4%	62.6%
NER	Benchmark	5,198	$ 509.1K	67.6%	64.7%	73.2%	68.5%	89.8%
	No Neg Safety Level	5,198	$ 558.4K	67.1%	64.4%	72.7%	68.1%	89.8%

The table shows that increasing the minimum protection level from 2% to 50% results in a dollar value increase of 25% for ER items and 10% for NER items. There was no significant impact on effectiveness.

It is noted that the effectiveness values for the alternative model were slightly lower in some cases as compared to the benchmark, even though the minimum protection level was raised from 2% to 50%. This result occurs due to the nature of the variable protection model. More specifically, under the benchmark, high demand/low cost items generally get high protection levels (> 85%) while low demand/high cost items generally receive protection levels less than 50%. Under the alternative model, these low demand/high cost items receive at least 50% protection level and the higher depth. To attain the same effectiveness goal as the benchmark, the protection level (and depth) for the high demand/low cost items had to be lowered, causing the overall effectiveness to decline.

2. Depth Rounding with Normal Distribution. The preliminary load list quantity is computed using the Normal distribution. Current policy dictates that .5 rounding be applied to the preliminary quantity to arrive at the final

load list quantity. For example, the load list quantity would be seven if the preliminary quantity was 6.5, but the load list quantity would only be six if the preliminary quantity was 6.4. An alternative test load was built with a roundup policy. This policy rounds the preliminary load list quantity up to the next highest integer. Thus, an item having a preliminary quantity of either 6.4 or 6.5 would have a final load list quantity of seven. Both models were built to satisfy separate 85% net requisition effectiveness goals for ER and NER items. TABLE III compares the two alternative models.

TABLE III

Comparison of .5 Rounding and Rounding Up

	Alternatives	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
ER	Benchmark	14,730	$2,418.4K	63.1%	59.7%	68.5%	77.7%	62.6%
	Roundup	14,730	$2,409.2K	63.2%	60.2%	68.6%	78.3%	62.6%
NER	Benchmark	5,198	$ 509.1K	67.6%	64.7%	73.2%	68.5%	89.8%
	Roundup	5,198	$ 493.3K	67.5%	64.9%	73.2%	68.6%	89.8%

The table shows that there is little difference between rounding at .5 or rounding up to the next higher integer. Generally, rounding up seems to give slightly better support for slightly less dollars.

3. Risk Criteria. The current model computes depth using a variable protection model designed to meet an essentiality-weighted requisitions short goal. For items with a demand history, demand (AQD) is used as a measure of essentiality. For items with no historical demand, essentiality is based on the ship MEC and tender MEC. Analysis of the candidate file showed that most of the candidate items had been assigned the highest possible MEC. This

condition may change in the future, however, as essentiality based on Mission Criticality Codes (MCCs) is implemented.

Three alternative test loads were built: (1) an essentiality-weighted units short model, (2) a demand-weighted units short model, and (3) a demand-weighted requisitions short model. The three test loads were built by changing the risk formula used to compute the depth for an item. The various risk formulas are shown below:

a. Current Model (Essentiality-Weighted Requisition Short)

(1) Historical Demand

$$\text{Risk} = \frac{\lambda \times \text{Unit Price} \times \text{Average Requisition Size}}{\text{AQD}}$$

(2) No historical Demand

$$\text{Risk} = \frac{\lambda \times \text{Unit Price}}{E}$$

b. Essentiality-Weighted Units Short

(1) Historical Demand

$$\text{Risk} = \frac{\lambda \times \text{Unit Price}}{\text{AQD}}$$

(2) No historical demand; same as current model

c. Demand-Weighted Units Short

All Items: $\text{Risk} = \frac{\lambda \times \text{Unit Price}}{\text{AQD}}$

d. Demand-Weighted Requisitions Short

All Items: $\text{Risk} = \frac{\lambda \times \text{Unit Price} \times \text{Average Requisition Size}}{\text{AQD}}$

where

λ = control parameter to achieve specified effectiveness goal

E = essentiality based on an item's ship and tender MEC and population

More specifically, $E = \dfrac{(POP_S \times E_S) + (POP_T \times E_T)}{\Sigma POP}$

where

POP_S = ship installable population

E_S = ship MEC smoothed to a value between 0 and 1

POP_T = tender installable population

E_T = tender MEC smoothed to a value between 0 and 1

$\Sigma POP = POP_S + POP_T$

The benchmark and demand-weighted requisitions short models were built to satisfy separate 85% net requisition effectiveness goals for ER and NER items. The essentiality-weighted units short and demand-weighted units short models were built to satisfy separate 85% net units effectiveness goals for ER and NER. TABLE IV shows the comparison between the benchmark and the three test loads.

It is noted that NER items by definition have historical demand. Therefore, for NER items, the benchmark and demand-weighted requisitions short models are identical and the essentiality-weighted units effectiveness and demand-weighted units short models are identical.

TABLE IV

Alternative Risk Criteria

	Alternative	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
ER	Benchmark	14,730	$2,418.4K	63.1%	59.7%	68.5%	77.7%	62.6%
ER	Ess. Weighted Units Short	14,730	$2,308.0K	62.6%	57.6%	68.0%	74.9%	62.6%
ER	Dmd-Weighted Units Short	14,730	$2,278.6K	59.2%	51.4%	64.3%	66.8%	62.6%
ER	Dmd-Weighted Reqn Short	14,730	$2,489.5K	57.7%	54.1%	62.6%	70.3%	62.6%
NER	Benchmark	5,198	$ 509.1K	67.6%	64.7%	73.2%	68.5%	89.8%
NER	Dmd-Weighted Units Short	5,198	$ 330.2K	59.0%	42.5%	63.9%	44.9%	89.8%

For ER items, the essentiality-weighted units short model decreased effectiveness up to 2.8 percentage points while decreasing costs by less than 5%. Neither the demand-weighted units short model nor the demand-weighted requisitions short model performed as well as the benchmark. The demand-weighted units short model had lower effectiveness than the benchmark and less than a 6% difference in cost. The demand-weighted requisitions short model had lower effectiveness and a higher cost than the benchmark.

The demand-weighted units short model had a significant impact on NER items. Effectiveness decreases ranged from 8.6 to 23.6 percentage points, while costs decreased by over 35%. Further analysis showed that the benchmark (built to satisfy 85% net requisition effectiveness) had predicted net units effectiveness of 93.0% for ER and 98.1% for NER. Thus, if a units effectiveness goal is desired, that goal would have to be set higher than 85% to maintain the current level of effectiveness. The costs associated with a demand-weighted units short load built with the net units effectiveness goals of 93.0% for ER and 98.1% for NER are $2,581.0K for ER and $819.4K for NER.

Overall, the benchmark performs better than the models testing alternative risk criteria.

4. AQD Computation for ER Items. An item having historical demand over a specified two year period has its demand forecast (AQD) based on that historical demand. If there is no historical demand, then the forecast is computed by BRF x population (AQD_{BRF}). A test model was built which computed the AQD both ways (demand and BRF x population) and took the larger of the two AQDs for determining depth. TABLE V displays the impact on costs and effectiveness of this alternative model, which was built with an 85% net requisition effectiveness goal. This alternative only impacts on ER items since all NER items have historical demand.

TABLE V

AQD Logic Comparison

	Alternative	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
	Benchmark	14,730	$2,418.4K	63.1%	59.7%	68.5%	77.7%	62.6%
E R	Max (AQD_{DMD}, AQD_{BRF}) - Eff Goal	16,491	$3,176.2K	68.4%	66.8%	71.8%	80.5%	70.4%
	Max (AQD_{DMD}, AQD_{BRF})- $ Goal	16,491	$2,712.5K	22.0%	41.0%	23.1%	49.5%	70.4%

The table shows that the alternative model increases cost by about 31% but also significantly increases effectiveness. Requisition and units effectiveness increases ranged from 2.8 to 7.1 percentage points while range effectivaness increased by 7.8 percentage points.

Since the alternative discussed above produced such a large increase in dollar value over the benchmark, an attempt was made to build the Max (AQD_{DMD}, AQD_{BRF}) alternative with a dollar goal, vice effectiveness goal. As TABLE V shows, the lowest attainable cost for this alternative was $2.7M, or about $300K above the benchmark dollar goal. Even at this cost, units and requisitions effectiveness values were greatly decreased from the benchmark. These decreases ranged from 18.7 to 45.4 percentage points.

In summary, the two alternatives provided inconsistent results. The alternative built with an 85% net requisition effectiveness goal came close to meeting that goal but caused a sizeable increase in costs. At the lower dollar value level, the alternative performed poorly.

5. Depth Constraints for Items with No Historical Demand. Depth constraints are normally applied to items with no historical demand. More specifically, items with no historical demand are constrained to a maximum load list quantity of 50 and a maximum extended dollar value of $100. For the purpose of this study, those depth constraints were not applied to most of the test loads so as not to distort the impact of the various alternatives. However, the following four test loads were built to evaluate different combinations of the depth constraints:

- Maximum quantity - 50; maximum extended dollar value - $100
- Maximum quantity - 50; maximum extended dollar value - $500
- Maximum quantity - 50; maximum extended dollar value - $1,000
- Maximum extended dollar value - $100

TAVLE VI displays the results of these alternatives. Note: These alternatives only apply to ER items since all NER items have historical demand.

TABLE VI

Depth Constraint Alternatives

Alternative	Range	Value	Model Units	Model Reqns	Net Reqns	Net Units	Range Eff.
Benchmark (No Constraint)	14,730	$2,418.4K	63.1%	59.7%	68.5%	77.7%	62.6%
Max Qty-50 Max $-$100	14,730	$2,504.9K	64.1%	62.3%	69.5%	81.0%	62.6%
Max Qty-50 Max $-$500	14,730	$2,592.6K	64.1%	62.4%	69.6%	81.1%	62.6%
Max Qty-50 Max $-$1,000	14,730	$2,611.5K	64.1%	62.4%	69.6%	81.1%	62.6%
No Qty Constraint Max $ $100	14,730	$2,432.4K	63.9%	61.4%	69.4%	79.9%	62.6%

The table indicates that the alternative model combining a maximum constraint of 50 and a maximum dollar value constraint of $100 improved effectiveness with a small increase in cost. More specifically, that alternative increased effectiveness from one to 3.3 percentage points and increased cost by less than 4%.

Raising the dollar constraint from $100 to either $500 or $1,000 had nearly no impact on effectiveness with a slight increase in cost, as compared to the alternative with quantity constraint of 50 and a $100 constraint. Eliminating the quantity constraint increased effectiveness by up to 2.2 percentage points with a less than 1% increase in costs, as compared to the benchmark.

In summary, a model built with a $100 constraint performs better than the benchmark.

6. Range Determination and Probability Distribution. The current model uses a range cut based on the expected units demanded over a two year period. More specifically, only candidate items which have at least four units of demand predicted for two years are placed on the load list. Two types of alternative range models were evaluated - an optimization model and a variable threshold model. No range cuts are used in an optimization model. Any item with a computed load list quantity of one or more is placed on the load list.

In the variable threshold model, the range is based on a criteria that ranks the candidates by the variable threshold value, PVTR. PVTR is defined as:

$$PVTR = \frac{1-P_A}{C}$$

where

$1-P_A$ = probability of having some demand

C = unit price

If PVTR exceeds a specified parameter value, the item is included on the load; otherwise, it is not included on the stockage list. The variable threshold model

generally stocks the high demand/low cost items and does not stock the low demand/high cost items. In this study, separate parameter values were used for stocked and not stocked items, based on the previous load list quantity. Parameter values were selected so that items currently stocked in the load would have a better chance of being selected for the new load.

A total of 15 alternative range models were evaluated for ER items. Six of those 15 alternatives were evaluated for NER items. These alternative models were built with varying assumptions concerning the probability distribution and the applicable goal for which the load was built. More specifically, two of the optimization models assumed a normal probability distribution. The remaining models assumed a Poisson/Normal distribution. Using that distribution, the Poisson distribution was used for items with a predicted AQD less than or equal to one. The Normal distribution was used for items with a predicted AQD greater than one. Each range model was built with either an effectiveness, range, or dollar goal. These goals were based on the values predicted by the benchmark. Three of the 15 ER test loads were built with separate effectiveness, range, and dollar goals for 9 cog ER items and non 9 cog ER items.

It should be noted that although net effectiveness values are presented in the results, those performance measures are not valid criteria when comparing alternatives with significantly different ranges. The model effectiveness values are the pertinent performance measures in this section.

TABLE VII shows the impact of the alternative range models on ER items. The two optimization models with the Normal distribution (lines 2 and 3) significantly increased dollar value. For example, the requisition short model (line 3) increased costs by over 150%. Additionally, effectiveness decreased sharply, including a 35.8 percentage point decrease in range effectiveness.

TABLE VII

Alternative ER Optimization Models

Line	Risk Criteria	Probability Distribution	Goal	Range	Value	Model Units	Model Requisitions	Net Units	Net Requisitions	Range Eff.
1	Ess-Weighted Rqn Short (Benchmark)	Normal	Effectiveness	14,730	$2,418.4K	63.1%	59.7%	68.5%	77.8%	62.6%
2	Ess-Weighted Rqn Short (Optimization)	Normal	Effectiveness	47,327	$6,168.5K	60.7%	51.9%	66.1%	79.5%	52.3%
3	Dmd-Weighted Rqn Short (Optimization)	Normal	Effectiveness	12,952	$6,100.1K	48.5K	31.8%	62.3%	75.6%	26.8%
4	Ess-Weighted Rqn Short (Optimization)	Poisson/ Normal	Effectiveness	[illegible]8,069	$ 777.5K	61.2%	51.8%	67.3%	80.3%	49.2%
5	Dmd-Weighted Rqn Short (Optimization)	Poisson/ Normal	Effectiveness	[illegible]36	$ 7[illegible]3.6K	48.6%	31.7%	62.8%	76.0%	25.7%
6	Dmd-Weighted Rqn Short (Optimization)	Poisson/ Normal	Effectiveness (Sep for 9 cog/ non 9 cog)	8,825	$ 779.0K	54.4%	40.0%	63.1%	78.7%	34.9%
7	Dmd-Weighted Units Short (Optimization)	Poisson/ Normal	Effectiveness	13,255	$1,401.9K	63.4%	52.8%	69.1%	81.5%	48.9%
8	Variable Threshold	Poisson/ Normal	Effectiveness	14,906	$ 654.3K	58.4%	47.4%	66.0%	80.3%	45.1%
9	Dmd-Weighted Rqn Short (Optimization)	Poisson/ Normal	Range	14,353	$1,391.5K	61.3%	51.7%	67.6%	80.5%	48.4%
10	Dmd-Weighted Rqn Short (Optimization)	Poisson/ Normal	Range (Sep for 9 cog/non 9 cog)	14,910	$2,101.8K	61.5%	52.3%	67.5%	80.3%	49.2%
11	Dmd-Weighted Units Short (Optimization)	Poisson/ Normal	Range	14,992	$1,557.0K	63.9%	55.0%	69.2%	81.7%	52.2%
12	Ess-Weighted Rqn Short (Optimization)	Poisson/ Normal	Dollar	40,316	$2,392.5K	67.0%	71.9%	68.6%	82.9%	78.3%
13	Dmd-Weighted Rqn Short (Optimization)	Poisson/ Normal	Dollar	23,868	$2,388.1K	65.7%	63.7%	68.6%	81.8%	65.1%
14	Dmd-Weighted Rqn Short (Optimization)	Poisson/ Normal	Dollar (Sep for 9 cog/non 9 cog)	21,035	$2,357.7K	65.1%	61.0%	68.7%	81.9%	61.0%
15	Dmd-Weighted Units Short (Optimization)	Poisson/ Normal	Dollar	22,889	$2,403.2K	66.1%	64.3%	68.9%	82.3%	65.4%
16	Variable Threshold	Poisson/ Normal	Dollar	45,901	$2,394.6K	67.3%	72.4%	68.5%	82.7%	79.5%

Lines 4-8 represent alternative range models built with an effectiveness goal and the Poisson/Normal distribution. The demand-weighted units short model (line 7) provided a lower cost and range and higher model unit effectiveness than the benchmark. However, the model requisition effectiveness decreased 6.9 percentage points and range effectiveness decreased 13.7 percentage points. The other four models (lines 4, 5, 6, and 8) all provide about the same costs. Of these models, the essentiality-weighted model (line 4) provided the best effectiveness.

The demand-weighted units short model (line 7) and especially the two demand-weighted requisitions short models (lines 5 and 6) all produced loads with a significantly lower range than the benchmark. In order to analyze the impact of the range differences, these three loads were built with a range goal, vice effectiveness goal, and using the Poisson/Normal distribution, as shown in lines 9, 10, and 11, respectively. The demand-weighted units short model (line 11) provided higher effectiveness than the other two models. As compared to the benchmark, the demand-weighted units short model (line 11) provided lower cost and better effectiveness except for model requisition effectiveness and range effectiveness, where decreases were 4.7 and 10.4 percentage points, respectively.

Thus far, the alternative models built with the Poisson/Normal distribution all provided significantly lower costs than the benchmark. To evaluate the performance of alternative range models at a given cost, additional test loads were built with a cost goal. Models 4-8 were rebuilt with a cost goal and are represented by lines 12-16, respectively. These five models were the only alternatives which provided higher effectiveness than the benchmark in all categories. Lines 12 and 16 produced ranges exceeding 40,000 items in order to meet the dollar goal. The other three models (lines 13-15) produced ranges approximately 50% higher than the benchmark, with the units short model performing best.

TABLE VIII shows the impact on NER items of six alternative range models.

TABLE VIII

Alternative NER Optimization Models

Line	Risk Criteria	Probability Dist.	Goal	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
1	Dmd-weighted Reqn Short (Benchmark)	Normal	Eff.	5,198	$509.1K	67.6%	64.7%	73.2%	68.5%	89.8%
2	Dmd-weighted Reqn Short (Optimization)	Normal	Eff.	4,456	$471.2K	68.1%	63.9%	74.8%	71.3%	80.9%
3	Dmd-weighted Reqn Short (Optimization)	Poisson/ Normal	Eff.	4,474	$493.1K	68.4%	64.4%	75.0%	71.8%	81.1%
4	Dmd-weighted Units Short (Optimization)	Poisson/ Normal	Eff.	4,815	$788.3K	69.9%	67.6%	76.1%	73.7%	84.4%
5	Variable Threshold-Dmd-weighted Reqn Short	Poisson/ Normal	Eff.	5,010	$506.5K	68.3%	65.0%	74.1%	69.5%	87.7%
6	Dmd-weighted Reqn Short (Optimization)	Poisson/ Normal	Range	5,053	$778.2K	70.2%	70.5%	76.2%	74.9%	88.6%
7	Dmd-weighted Units Short (Optimization)	Poisson/ Normal	Range	5,144	$984.5K	70.6%	71.5%	76.5%	75.7%	89.3%

TABLE VIII shows that lines 4, 6, and 7 all produced significantly higher costs than the benchmark. The remaining three models, all built with an effectiveness goal, provide similar results. These are the demand-weighted requisitions short - Normal model (line 2), demand-weighted requisitions short - Poisson/Normal model (line 3), and the variable threshold model (line 5). Line 5 provides similar model units effectiveness and higher model requisitions effectiveness and range effectiveness than the two demand-weighted requisitions short models. However, the demand-weighted requisitions short models cost less and provide higher net effectiveness than the variable threshold model.

Additional test loads were built that combined optimization models with the depth constraint alternatives described in Section 5. TABLE IX shows the results of five loads built with and without a quantity constraint of 50 and an extended dollar value constraint of $100 applied to items with no historical demand. These four loads were (1) the benchmark, (2) an optimization demand-weighted requisitions short model built with an effectiveness goal, (3) an optimization demand-weighted requisitions short model built with a range similar to the benchmark, and (4) an optimization demand-weighted units short model with a range similar to the benchmark, and (5) an optimization demand-weighted units short model built with a dollar goal. Since the depth constraints apply only to ER items, the results shown are for ER items only. In addition, the optimization models were built with the Poisson/Normal distribution, while the benchmark models were built with the Normal distribution.

TABLE IX

Alternative Range/Depth Constraint Models
(ER Items Only)

Alternative	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
Benchmark - No constraint	14,730	$2,418.4K	63.1%	59.7%	68.5%	77.7%	62.6%
Benchmark - w/constraint	14,730	$2,504.9K	64.1%	62.3%	69.5%	81.0%	62.6%
Opt Dmd-weighted Reqn Short Eff. Goal - No constraint	6,138	$ 733.6K	48.6%	31.7%	62.8%	76.0%	25.7%
Opt Reqn Short, Eff. Goal - W/constraint	18,265	$ 940.3K	63.8%	57.0%	68.4%	81.1%	55.9%
Opt Dmd-weighted Reqn Short, Range Goal - No constraint	14,353	$1,391.5K	61.3%	51.7%	67.6%	80.5%	48.4%
Opt Reqn Short, Range Goal - w/constraint	14,353	$ 786.7K	61.1%	51.6%	67.3%	80.3%	48.4%
Opt dmd-weighted Units Short, Range Goal - No constraint	14,992	$1,557.0K	63.9%	55.0%	69.2%	81.7%	52.2%
Opt dmd-weighted Units Short, Range Goal - w/constraint	14,992	$ 959.3K	63.7%	54.9%	68.9%	81.5%	52.2%
Opt Dmd-weighted Units Short $ Goal - No constraint	22,889	$2,403.2K	66.1%	64.3%	68.9%	82.3%	65.4%
Opt dmd-weighted Units Short $ Goal - w/constraint	36,300	$2,334.1K	67.1%	73.7%	68.5%	83.1%	80.6%

Considering the optimization model with an effectiveness goal, TABLE IX shows that applying the depth constraints increased effectiveness from 5.1 to 25.3 percentage points, increased the range by almost 200%, and increased the dollar value by 28%. On the other hand, providing a depth constraint for the optimization models with a range goal had a small impact on effectiveness but resulted in cost decreases of 43% and 38% for the requisitions short and units short models, respectively. As discussed in Section 5, applying the depth constraints to the benchmark increased costs by less than 4% and increased effectiveness by a maximum of 3.3 percentage points. For the demand-weighted units short optimization model built with a dollar goal, applying the depth constraints significantly increased model effectiveness and range effectiveness, but also increased the range by over 58%. Compared to the benchmark, the range increased by over 146%.

In summary, applying the depth constraints to either a range cut model or an optimization model built with a range goal appears beneficial. However, applying the depth constraints to an optimization model built with an effectiveness goal or dollar goal (which is really a higher effectiveness goal) may expand the range beyond a satisfactory limit.

As noted previously, the demand-weighted units short optimization model was the most cost effective alternative for ER items. An area not discussed as of yet is the impact on Depot Level Repairables (DLRs). Optimization models tend to stock high demand/low cost items and thus may hurt support for DLR items.

Analysis of the DLR items on the benchmark and the demand-weighted units short optimization models showed that this indeed is the case. Both of these models were built with specific goals for ER items, of which the DLR items make up a small subset. TABLE X displays the DLR results for those two models.

TABLE X

Benchmark and Demand-Weighted Units Short Optimization Impact on DLR Items

Alternatives	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
Benchmark (85% net Eff. goal for ER items)	516	$1,083.7K	33.5%	29.3%	53.7%	59.6%	39.7%
Demand-Weighted Units Short Optimization ($2.4M Goal for ER Items)	156	$ 397.1K	27.0%	12.7%	80.0%	80.2%	12.[illegible]

TABLE X shows that compared to the benchmark, the optimization model significantly decreased range, dollar value, model units and requisitions effectiveness, and range effectiveness. The net effectiveness figures are provided for information only. This is not a valid performance measure when comparing loads of significantly different ranges.

In order to compare the impact on DLR items fairly, two additional models were built. First, the benchmark was built for DLR items only. In other words, the load was built to satisfy an 85% net requisition effectiveness goal for DLR items. Secondly, a demand-weighted units short optimization model was built for DLR items with a goal of achieving the same cost as the DLR benchmark. TABLE XI presents the results of these two new models.

TABLE XI

DLR Benchmark and DLR Demand-Weighted Units Short Optimization Model

Alternative	Range	Value	Model Units	Model Rqn	Net Units	Net Rqn	Range
DLR Benchmark (85% Net Rqn Eff Goal-DLR)	516	$1,839.1K	51.7%	40.2%	82.7%	81.6%	39.7%
DLR Dmd-Weighted Units Short Optimization ($Goal-DLR)	863	$1,859.7K	54.5%	44.1%	83.2%	82.7%	46.3%

TABLE XI shows that for the same cost as the DLR benchmark, the DLR demand-weighted units short optimization model increases the range, units and requisition effectiveness, and range effectiveness. These results are consistent with those shown for the total ER data base.

Results for the alternative range models can be summarized as follows: For ER items, the demand-weighted units short model performs best for a given goal. The most cost-effective model is the demand-weighted units short model built with a dollar goal. For the same cost, this model increased effectiveness over the benchmark by up to 4.6 percentage points but with a 50% increase in range. This would be the preferred model if the additional workload resulting from the increased range is tolerable. Additional analysis showed that this model resulted in a predicted gross units effectiveness value of 93.2%. Thus, if a cost goal is not appropriate, the identical model can be built with a 93% gross units effectiveness goal. Also, there should be separate goals for DLR, ER, and NER items.

For NER items, three models built with an effectiveness goal performed the best. These were the demand-weighted requisitions short models built with either the Normal or Poisson/Normal distribution and the variable threshold model. To be consistent with the ER model for which an optimization model is preferred, one of the demand-weighted requisitions short models is the preferred NER model.

IV. ANALYSIS OF THE LA MADDALENA SITE TENDER LOAD

A. <u>AS 18 Candidate File Analysis</u>. The AS 18 test loads were based on demand history from the supported submarines for the two year period January 1977 through December 1978. There were 105,498 ER candidates for the AS 18. Only 10,164 (9.6%) of these ER candidates had historical demand during the selected two year period. Demand forecasts for the remaining 95,334 were based on the

BRF and population. Characteristics of the ER candidates are shown in Appendix D and summarized below:

- Over 81% (85,937) of the ER candidates had an AQD of 1.00 or less.
- Almost 90% (94,785) of the ER candidates had an average requisition size of zero or one.
- Almost 22% (22,797) of the ER candidates had a unit price of $1 or less and over 78% (82,642) had a unit price of $100 or less.
- 90% (95,366) of the ER candidates had a ship MEC of 116.
- 89% (94,219) of the ER candidates had a zero tender MEC. Of the 11,273 having a tender MEC, all but six had 58 for the tender MEC.

There were 21,279 NER candidates for the AS 18. Of these, 10,530 were excluded because they had only a single demand frequency in two years or a total two year demand quantity of four units or less. Thus, 10,749 NER candidates were considered in this study. Characteristics for these items are shown in Appendix E and are summarized below:

- Over 54% (4,934) of the NER candidates had an AQD greater than one.
- Over 35% (3,801) of the NER candidates had an average requisition size of zero or one.
- 28% (3,008) of the NER candidates had a unit price of $1 or less and almost 90% (9,663) had a unit price of $100 or less.

The loads were evaluated using demand from two nonconsecutive quarters - June through August 1979 and January through March 1980.

TABLE XII displays the characteristics of these demand data:

TABLE XII

Demand Characteristics

	June - August 1979			January - March 1980		
Item Category	Items Demanded	Nr. Reqns	Nr. Units	Items Demanded	Nr. Reqns	Nr. Units
Candidates	2,621 (77.3%)	9,239 (88.5%)	163,589 (78.5%)	2,312 (77.3%)	7,116 (85.9%)	122,800 (90.9%)
Noncandidates	771 (22.7%)	1,197 (11.5%)	44,722 (21.5%)	678 (22.7%)	1,171 (14.1%)	12,359 (9.1%)
Total	3,392	10,436	208,311	2,990	8,287	135,159

The table shows that over 75% of the items, 85% of the requisitions and 78% of the units demanded had NIINs identified on the candidate file.

B. La Maddalena Load List Analysis. The analysis of the La Maddalena site tender load consists of two parts. First is an evaluation of an alternative range criterion, and secondly, several depth criteria were evaluated by varying the percent of AQD used in the depth determination.

1. Alternative Range Criterion. Current policy states that the AS (SSN) load list range will be determined by a range cut applied to each candidate item's AQD. The AQD is based on the expected demand from the submarine tender's hull mix, normally not more than 20 submarines. In the case of the AS 18, however, the AQD was based on 37 hulls even though only nine submarines were expected to be supported in any given quarter.

The range criterion evaluated in this study adjusted an item's AQD by multiplying it by the probability that if an item is demanded by one of the 37 submarines in a quarter, it will be demanded from the tender. The range cut is then applied to this adjusted AQD. The probability values were based

on the hypergeometric probability distribution. The formula used to adjust the AQD was:

$$\text{ADJUSTED AQD} = (\text{AQD}) \times \quad 1 - \frac{\binom{N}{0} \binom{37-N}{9}}{\binom{37}{9}}$$

where

N = number of ships on which item is installed

$1 - \frac{\binom{N}{0} \binom{37-N}{9}}{\binom{37}{9}}$ = probability of the tender receiving demand from one of the 37 submarines, depending on the value of N. The value of "N" was determined from the ICP candidate file of APL items.

The AQD for NER items was not adjusted since NER items are not identified on the ICP candidate file. Thus, only ER items were considered in this analysis. TABLE XIII displays the probability values for each value of "N".

TABLE XIII

Probability Values Used to Adjust AQD
For ER Items

N Number of Ships on Which Item is Installed	Probability Values = Probability of the Tender Receiving Demand From One of the 37 Submarines (Depends on Value of "N")
1	.243
2	.432
3	.578
4	.690
5	.775
6	.838
7	.885
8	.919
9	.944
10	.962
11	.975
12	.984
13	.989
14	.993
15	.996
16 - 37	1.000

The benchmark for the AS 18 was built exactly as the AS 12s. More specifically, the Normal probability distribution describes item demand, range is determined by a range cut, depth is computed using a variable protection model based on essentiality-weighted requisitions short, and separate 85% net requisition effectiveness goals are used for ER and NER items. The only difference between the benchmark and the alternative range criterion

is that under the alternative range criterion, the AQD is factored down by the appropriate probability value prior to applying the range cut. TABLEs XIV and XV display the results for the time periods June through August 1979 and January through March 1980, respectively.

TABLE XIV

Alternative Range Criterion
(Jun - Aug 1979)

	Alternative	Range	Value	Gross Units	Gross Reqns	Net Units	Net Reqns	Range Eff.
E	Benchmark	21,422	$6,665.3K	57.5%	71.1%	58.4%	78.0%	85.4%
R	Range based on Adjusted AQD	19,367	$6,222.2K	57.3%	70.1%	58.7%	78.1%	83.5%

TABLE XV

Alternative Range Criterion
(Jan - Mar 1980)

	Alternative	Range	Value	Gross Units	Gross Reqns	Net Units	Net Reqns	Range Eff.
E	Benchmark	21,442	$6,665.3K	63.9%	77.2%	67.1%	86.1%	83.8%
R	Range based on Adjusted AQD	19,367	$6,222.2K	63.6%	75.3%	67.6%	86.2%	80.9%

The tables show that the alternative range criterion has only minor impact on cost and effectiveness. The maximum difference in requisition or units effectiveness is 1.9 percentage points. Besides not providing any significant improvement over the benchmark, the range alternative would incur an extra

implementation cost. This cost would occur due to the additional Weapon Systems File (WSF) extracts necessary to determine the value of "N".

2. Alternative Depth Criteria. The current La Maddalena load list depth was computed by multiplying each item's AQD by .25. This was done since the AS 18 would service approximately nine of 37 submarines in any given 90 day period. Test loads were built that factored an item's AQD by .15, .5, and 1.0. The current AS(SSN) model uses a parameter value of 1.0. In addition, two test loads were built with an AQD factor of 1.0 and with range cuts of eight and six, vice four. TABLEs XVI and XVII show the comparisons of the various depth alternatives for the two different quarters of demand.

TABLE XVI

Alternative Depth Criteria
(Jun - Aug 1979)

	Alternative	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
ER	Benchmark(.25)	21,442	$6,665.3K	57.5%	71.1%	58.4%	78.0%	85.4%
	.15 Factor	21,442	$6,293.8K	49.4%	67.3%	50.2%	73.8%	85.4%
	.50 Factor	21,442	$7,425.1K	67.8%	77.7%	68.9%	85.2%	85.4%
	1.0 Factor	21,442	$8,518.2K	78.9%	81.7%	80.2%	89.6%	85.4%
	1.0 Factor Range cut = 8	13,837	$6,582.4K	78.2%	76.2%	80.4%	89.4%	75.5%
	1.0 Factor Range cut = 6	16,665	$7,297.2K	78.6%	78.9%	80.3%	89.6%	80.3%
NER	Benchmark	7,092	$ 546.8K	40.8%	51.9%	42.5%	55.1%	87.8%
	.15 Factor	7,092	$ 493.5K	32.7%	44.7%	34.0%	47.5%	87.8%
	.50 Factor	7,092	$ 659.1K	54.5%	61.7%	56.8%	65.5%	87.8%
	1.0 Factor	7,092	$ 860.0K	69.3%	71.7%	72.2%	76.1%	87.8%
	1.0 Factor Range cut = 8	6,006	$ 613.4K	69.0%	70.4%	72.2%	76.7%	83.4%
	1.0 Factor Range Cut = 6	6,689	$ 761.0K	69.3%	71.4%	72.3%	76.7%	86.4%

TABLE XVII

Alternative Depth Criteria
(Jan - Mar 1980)

	Alternative	Range	Value	Model Units	Model Reqns	Net Units	Net Reqns	Range Eff.
E R	Benchmark	21,442	$6,665.3K	63.9%	77.2%	67.1%	86.1%	83.8%
	.15 Factor	21,442	$6,293.8K	56.4%	72.6%	59.2%	81.0%	83.8%
	.50 Factor	21,442	$7,425.1K	73.2%	82.7%	76.8%	92.2%	83.8%
	1.0 Factor	21,442	$8,518.2K	83.2%	86.3%	87.3%	96.2%	83.8%
	1.0 Factor Range Cut = 8	13,837	$6,582.4K	82.4%	80.3%	87.7%	96.3%	74.3%
	1.0 Factor Range Cut = 6	16,665	$7,297.2K	82.8%	83.2%	87.5%	96.2%	78.9%
N E R	Benchmark	7,092	$ 546.8K	53.0%	62.2%	56.3%	65.5%	88.8%
	.15 Factor	7,092	$ 493.5K	42.4%	54.5%	45.0%	57.5%	88.8%
	.50 Factor	7,092	$ 659.1K	69.2%	72.6%	73.5%	76.5%	88.8%
	1.0 Factor	7,092	$ 860.0K	83.9%	80.6%	89.2%	85.0%	88.6%
	1.0 Factor Range Cut = 8	6,006	$ 613.4K	83.7%	79.1%	89.2%	85.9%	83.8%
	1.0 Factor Range Cut = 6	6,689	$ 761.0K	83.9%	80.3%	89.3%	85.7%	87.3%

The tables show that increasing the AQD factor to either .50 or 1.0 increased both cost and effectiveness as compared to the benchmark. For example, TABLE XVI shows that applying a .50 factor increased cost by 11.4% and increased effectiveness from 6.6 to 10.5 percentage points; while applying the 1.0 factor increased cost by 27.8% and increased effectiveness from 10.6 to 21.8 percentage points, for ER items.

The tables indicate that the most cost-effective alternative was built by applying a 1.0 factor and doubling the range cut to eight. More specifically,

TABLE XVII shows that for ER items, this alternative decreased cost by less than 2% while increasing units and requisition effectiveness 3.1 to 20.6 percentage points; and for NER items, the alternative increased cost by less than 15% while increasing effectiveness 16.9 to 32.9 percentage points. This alternative decreased range effectiveness for both ER and NER items.

In summary, the model built by applying a 1.0 factor to the AQD and increasing the range cut to either six or eight performs better than either the benchmark or the other alternatives. If the decrease in range effectiveness is a concern, then applying a range cut of six would be preferable.

V. SUMMARY AND RECOMMENDATIONS

The purpose of this study was twofold. First, the current AS(SSN) tender load list model was evaluated. Areas evaluated included risk constraints, depth rounding, risk criteria, AQD computation for ER items, depth constraints for items with no historical demand, range determination, and probability distribution.

Results of this study indicate that the most cost-effective model for ER items is a demand-weighted units short optimization model, built with the Poisson/Normal distribution and a high effectiveness goal or a current dollar goal. This alternative, at about the same cost as the benchmark, increased units, requisitions, and range effectiveness by up to 4.6 percentage points, but also increased the range by over 50%. For NER items the most cost-effective model is a demand-weighted requisitions short optimization model, built with either the Poisson/Normal or Normal distribution and an effectiveness goal. As compared to the benchmark, these two NER models produced, at a lower range and cost, higher net effectiveness and model units effectiveness,

and lower model requisition effectiveness and range effectiveness. These ER/NER models were also recommended by the reference (a) study. It is recommended that the Type Commanders validate whether the increased ER range would create a cube problem for the tenders. If the increased range can be accommodated, implementation efforts should address how the goal is set and whether the 50 unit/$100 constraint should be applied to items with no historical demand. If the increased range cannot be accommodated, the current range cut model should be retained with the rounding rule changed to always round up. In either case, separate goals are recommended for DLRs, ER items, and NER items.

The second purpose of the study was to evaluate test loads built for the La Maddalena site tender. The unique problem in building the La Maddalena load was that although the load was built to support 37 submarines, only about nine submarines will be supported in a given quarter. Thus, alternative range and depth criteria for building the La Maddalena load list were evaluated. Results show that the range alternative had little impact on cost or effectiveness. As for the depth alternatives, increasing the AQD factor from the current .25 to either .50 or 1.0 increased cost and effectiveness. The most cost-effective alternative, and the one recommended, was built by applying a 1.0 factor to the AQD for depth purposes and increasing the range cut from four to either six or eight. This alternative decreased cost by less than 2% while units and requisitions effectiveness increases range from 3.1 to 20.6 percentage points for ER items.

APPENDIX A: REFERENCES

1. FMSO Operations Analysis Report 130 - Conventional AS Load List Study of 20 September 1977.

APPENDIX B: USS SPERRY (AS 12) CANDIDATE ITEM CHARACTERISTICS

The tables shown in the following pages display various characteristics of USS SPERRY's candidate items. Distributions shown include AQD, Unit Price, MEC, Average Requisition Size, and a comparison of the ER candidate items with 90 days of actual demand.

List of Tables

TABLE I

USS SPERRY
Predicted Average Quarterly Demand for ER Items

Predicted AQD ≤	Cumulative Nr. Items	Cumulative %
0.001	10,849	11.5
0.1	59,149	62.8
0.5	81,076	86.0
1	85,965	91.2
5	91,870	97.0
10	92,917	98.6
100	94,115	99.9
1,000	94,238	99.9
10,000	94,243	99.9
100,000	94,244	100.0

TABLE II

USS SPERRY
Unit Price for ER Items

Unit Price ≤	Cumulative Nr. Items	Cumulative %
1	20,852	22.1
10	50,785	53.9
100	75,156	79.7
1,000	89,305	94.8
10,000	93,647	99.4
100,000	94,198	99.9
1,000,000	94,241	99.9
> 1,000,000	94,244	100.0

TABLE III

USS SPERRY
Ship MEC for ER Items
(94,244 Items)

Ship MEC	Nr. of Items	% of Total
59-115	9,5117	10.1%
116	84,727	89.9%

TABLE IV

USS SPERRY
Tender MEC for ER Items
(94,244 Items)

Tender MEC	Nr. of Items	% of Total
0	84,006	89.1%
1-57	10	< .001%
58	10,228	10.9%

TABLE V

USS SPERRY
Average Requisition Size for ER Items

ARS ≤	Cumulative Nr. Items	Cumulative %
1	86,929	92.2%
1.5	88,030	93.4%
2	89,701	95.2%
3	90,833	96.4%
4	91,594	97.2%
5	92,150	97.8%
10	93,172	98.9%
> 10	94,244	100.0%

TABLE VI

USS SPERRY
Predicted Average Quarterly Demand for NER Items

Predicted AQD ≤	Cumulative Nr. Items	Cumulative %
0.001	5,332	50.8
0.1	5,332	50.8
0.5	5,338	50.8
1	6,425	61.2
5	8,728	83.1
10	9,396	89.5
100	10,369	98.8
1,000	10,489	99.9
10,000	10,499	99.9
100,000	10,500	100.0

TABLE VII

USS SPERRY
Unit Price for NER Items

Unit Price ≤	Cumulative Nr. Items	Cumulative %
1	3,005	28.6
10	7,150	68.1
100	9,377	89.3
1,000	10,205	97.2
10,000	10,442	99.4
100,000	10,500	100.0
1,000,000	10,500	100.0
> 1,000,000	10,500	100.0

TABLE VIII

USS SPERRY
Average Requisition Size for NER Items

ARS ≤	Cumulative Nr. Items	Cumulative %
1	5,485	52.2
1.5	5,908	56.3
2	6,512	62.0
3	7,372	70.2
4	7,921	75.4
5	8,256	78.6
10	9,160	87.2
> 10	10,500	100.0

TABLE IX

USS SPERRY
ER Candidate/Actual Demand Comparison
(Demand Period: Jul - Sep 1979)

A.	ER Candidates with Demand in 90 days	4,904
B.	Nr. in "A" with AQD based on BRF x POP	1,623 (33.1%)
C.	Requisitions demanded in 90 days	10,882
D.	Nr. In "C" for items with AQD based on BRF x POP	2,380 (21.9%)
E.	Units demanded in 90 days	111,369
F.	Nr. in "E" for Items with AQD based on BRF x POP	16,458 (14.8%)

APPENDIX C: USS ORION (AS 18) CANDIDATE ITEM CHARACTERISTICS

The tables shown in the following pages display various characteristics of the USS ORION's candidate items. Distributions show AQD, Unit Price, MEC, Average Requisition Size, and a comparison of the ER candidate items with 90 days of actual demand.

List of Tables

TABLE I

USS ORION
Predicted Average Quarterly Demand for ER Items

Predicted AQD ≤	Cumulative Nr. Items	Cumulative %
0.001	13,766	13.0%
0.1	58,459	55.4%
0.5	85,937	81.5%
1	92,816	88.0%
5	101,358	96.1%
10	103,085	97.7%
100	105,168	99.7%
1,000	105,442	99.9%
10,000	105,494	99.9%
100,000	105,498	100.0%

TABLE II

USS ORION
Unit Price for ER Items

Unit Price ≤	Cumulative Nr. Items	Cumulative %
$1	22,797	21.6%
$10	54,735	51.9%
$100	82,642	78.3%
$1,000	99,505	94.3%
$10,000	104,716	99.3%
$100,000	105,438	99.9%
$1,000,000	105,493	99.9%
> $1,000,000	105,498	100.0%

TABLE III

USS ORION
Ship Mec for ER Items
(105,498 Items)

Ship MEC	Nr. of Items	% of Total
0	7,391	7.1%
59-115	2,741	2.5%
116	95,366	90.4%

TABLE IV

USS ORION
Tender MEC for ER Items
(105,498 Items)

Tender MEC	Nr. of Items	% of Total
0	94,219	89.3
1-57	6	< .1
58	11,273	10.7

TABLE V

USS ORION
Average Requisition Size for ER Items

ARS ≤	Cumulative Nr. Items	Cumulative %
1	94,785	89.8%
1.5	96,701	91.7%
2	99,131	94.0%
3	100,672	95.4%
4	101,799	96.5%
5	102,517	97.2%
10	104,029	98.6%
> 10	105,498	100.0%

TABLE VI

USS ORION
Predicted Average Quarterly Demand for NER Items

Predicted AQD ≤	Cumulative Nr. Items	Cumulative %
0.001	3,536	32.9%
0.1	3,536	32.9%
0.5	3,540	32.9%
1	4,934	45.9%
5	8,062	75.0%
10	8,995	83.7%
100	10,486	97.6%
1,000	10,733	99.9%
10,000	10,749	100.0%
100,000	10,749	100.0%

TABLE VII

USS ORION
Unit Price for NER Items

Unit Price ≤	Cumulative Nr. Items	Cumulative %
$1	3,008	28.0%
$10	7,270	67.6%
$100	9,663	89.9%
$1,000	10,450	97.2%
$10,000	10,691	99.5%
$100,000	10,749	100.0%
$1,000,000	-	
> $1,000,000	-	

TABLE VIII

USS ORION
Average Requisition Size for NER Items

ARS ≤	Cumulative Nr. Items	Cumulative %
1	3,801	35.4%
1.5	4,567	42.5%
2	5,479	51.0%
3	6,778	63.1%
4	7,449	69.3%
5	7,904	73.5%
10	9,107	84.7%
> 10	10,749	100.0%

TABLE IX

USS ORION
ER Candidate/Actual Demand Comparison
(Demand Period: Jun - Aug 1979)

A.	ER Candidates with demand in 90 days	1,149
B.	Nr. in "A" with AQD based on BRF x POP	311 (27.1%)
C.	Requisitions demanded in 90 days	2,193
D.	Nr. in "C" for items with AQD based on BRF x POP	523 (23.8%)
E.	Units demanded in 90 days	36,811
F.	Nr. in "E" for Items with AQD based on BRF x POP	6,316 (17.2%)

TABLE X

USS ORION
ER Candidate/Actual Demand Comparison
(Demand Period: Jan - Mar 1980)

A.	ER Candidates with Demand in 90 days	888	
B.	Nr. in "A" with AQD based on BRF x POP	306	(34.5%)
C.	Requisitions demanded in 90 days	1,506	
D.	Nr. in "C" for items with AQD based on BRF x POP	440	(29.2%)
E.	Units demanded in 90 days	23,398	
F.	Nr. in "E" for items with AQD based on BRF x POP	7,016	(30.0%)

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13. ABSTRACT

This study evaluated (1) alternative techniques for computing AS(SSN) tender load lists and (2) alternative range and depth criteria unique to the La Maddalena based tender load list. The various alternative test loads were evaluated using actual demand for a 90 day period. The models were evaluated in terms of units, requisitions, and range effectiveness. It is recommended that (1) the AS(SSN) load list be built with a demand-weighted units short optimization model for equipment-related items and a demand-weighted requisitions short optimization model for nonequipment-related items and (2) the La Maddalena site tender load be built using the full demand forecast vice a factored demand for depth, with the range cut increased from four to six or eight. It is also recommended that there be separate goals for Depot Level Repairables, equipment-related items, and nonequipment-related items.

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